To:

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Subject: Proton Improvement Plan

Project Quarterly Summary FY14 Q2

Report #9 April 21, 2014

Project Milestones

Linac achieved a couple of key milestones in this quarter, starting with one Level 3 for the Linac Laser Notch task and one Level 2 for HLRF task. The former milestone was related with the technology chosen for the beam shaping. Despite some loose ends, such as complete optimization and document the tests the team is confident that the beam stacker technique will work for this application. The latest, CPI team is on schedule with the development of the 201MHz Klystron system and a successful preliminary design review (PDR) was held in late March. The review went very well and the group is proceeding with NRE and is on track to have a CDR by the end of following quarter. Booster had no level 1 or 2 milestones and only one level 3 milestone. The Booster milestone was related to the new longitudinal damper and completed on time. The labor during the quarter has seen a ramp up as work and commissioning on MI and Recycler is being completed. The next two quarters of PIP will see more milestones including some higher level ones coming due. It is expected that with the additional labor, meeting the milestones should be achievable.

Level	WBS	Name	Baseline Date	Fcst Date	% Complete
3	1.02.03.02.01.08	Booster Damper prototype board testing complete	1/23/14	11/22/13	100%
3	1.01.01.02.10.01.09	Approval to Build 25 Cell Prototype Modulator	2/24/14	2/24/14	100%
3	.01.01.01.03.01.02.1	Preliminary Design Review Complete	4/18/14	3/27/14	100%
2	1.02.01.02.03.05	First Bias Supply Re-hab Complete	4/28/14	3/31/14	100%

Figure 1PIP FY14 Q2 milestone table

PIP Highlights by WBS Section

WBS 1.1 Linac

The vulnerabilities associated with the LINAC are the 200 MHz accelerating system, including power amplifier tubes and other associated systems such as the modulator; utilities for power distribution and vacuum systems; better need for reliable instrumentation along the Linac to improve beam transport and realistic machine model supported by real beam measurements. There are four largest elements of WBS Level 2 in Linac which are further subdivided at Level 3.

WBS 1.1.1 200MHz RF Power System

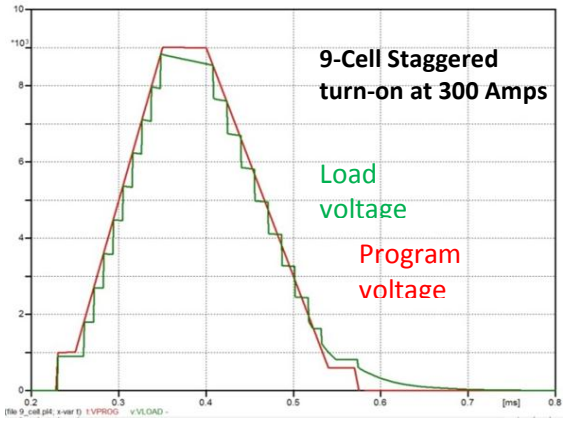
The 200MHz RF Power System represents approximately 40% of the total scope of the PIP project. There are 3 level 4 elements which will be described below.

WBS 1.1.1.1 High Level RF

During this quarter the CPI team was formed to develop the 201MHz klystron prototype for Fermilab. A kick off meeting was held in early February aimed to discuss in details all the specifications and reach

mutual agreement on them. A month later the preliminary design review (PDR) was held via web with participants from Fermilab, SLAC and CPI, reaching the completion of the first milestone within the klystron prototype task. Group members at Fermilab presented the upgrade plan at a public seminar held at Fermilab.

WBS 1.1.1.2 Linac Modulator



AD/EE Support Marx Modulator Design

This quarter was very productive for the Linac Modulator task. The technical team finished the mechanical building of the 9 cell prototype. The cells were tested at full loading current of 325A with 8kV peak. The cells were fired both sequentially and all at once and a slew rate of ~ 20kV/us at 80A was achieved, which is better than the 15kV/us request on the specification. The modulator was also successfully tested with both triangular and square waveform, matching simulation to test results, as shown on figure aside. During this test an analog based control system was used to create the desired wave shape which explain the discrete voltage step seen on the figure. In parallel with these tests, efforts continued until the end of this quarter developing a new pulse width modulation (PWM) board. Once this is complete, the cells will be tested to create interleave regulation which will be able to resolve the desire wave form without the discrete steps. The expectation is that PWM will be ready for testing at the beginning of Q3.

Enclosure design for the low voltage modulator prototype (25 cells) was also initiated during this quarter. Parts have been ordered from Fermilab machine shop on building all the cell interconnection parts which integrate the strip lines for both charging and gate power lines. Finally, an internal design review was held early March to determine the inputs and outputs of the overall control system, including the features of feed-back and feed-forward.

SLAC Marx Modulator Update

This quarter marked the completion of the third stage of modulator development for SCLAC, the control interface. Fermilab team members provided data on the 5MW triode amplifier and accelerating cavity for the simulation of a feed-forward. The approach taken for the feed-forward technique is to regulate the cavity gradient instead of the original design of regulating on modulator voltage. However, although the technique was successful to create a flat wave shape, the flat top regulation specification was not reached due to limited number of cells in the particular design. This can be compensated by incorporating a feed-back technique, but more studies need to occur in order to demonstrate the concept. During this quarter, SLAC team also started working on the enclosure designed for the P2 Marx (side figure).

WBS 1.1.1.3 7835 Procurement

During this quarter a new 7835 triode tube was received and first set of tests performed. This tube was acquired with supplemental funds received at end of FY13.

WBS 1.1.2 Accelerator Physics

WBS 1.1.2.1 Simulations and Studies

During this quarter, simulations were performed on the RFQ injector line. Using beam dynamics code TRACK, a systematic scan of both solenoids located upstream of the RFQ were performed. For each pair of values, beam intensity after the RFQ was recorded. Experimental data was also collected using the same method and compared with the simulation results. From the LEBT beam transmission point of view, simulations results are compatible with the experimental one.

WBS 1.1.2.2 *Not Used*

Some WBS numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established during the period of setting up PIP.

WBS 1.1.2.3 Linac Notch Creation

Good progress was accomplished this quarter on this task. The re-packaging of the seed laser and the optical modulator into the 19" rack mount Optical Pattern Generator and the re-packaging of the fiber pre-amplifier was complete. Also complete the construction of the relay rack for holding equipment and the optics box. The commissioning of the Piezo-electric mirrors for directing the laser into the optical cavity was successful commissioned during this period. Continue making progress on the final design of the vacuum chamber and optical cavity. At the end of the quarter, the team started commissioning and integrating the fiber amplifiers with the OPG.

WBS 1.1.3 Instrumentation

WBS 1.1.3.1 Beam Position Monitors

First Linac Level-3 WBS completed (FY13-Q2).

WBS 1.1.4 *Not Used*

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WBS 1.1.5 Utilities

The Linac Utilities, such as power distribution, water and vacuum systems are composed of mostly 40 year-old equipment beyond its practical service life. There are three Level 4 elements in this WBS.

WBS 1.1.5.1 Power Distribution

This year, the laboratory will have six weeks total shutdown planned (4 weeks fall in FY14 and 2 weeks in FY15). PIP management decided to move forward with the installation of the L1 transformer at this point in time. During the first quarter, a new L4 manager was appointed for the Linac Utilities task. The manager has been active planning this difficult installation, organizing meetings and evaluating the options. The installation plan is taking shape and expects to be complete by the next quarter.

WBS 1.1.5.2 LCW distribution

This WBS has been assigned to the necessary upgrades that are required for the Linac water systems in order to sustain reliable Linac operations. Two activities were identified and with available funds allocated for this fiscal year, the following tasks were initiated:

1. Installation of a backup 55 LCW pump at the Central Utility Building (CUB) and
2. Mitigate the re-occurrence of an eruption of a corrode Dual Temp System pipe at the Linac South Gallery Dual Temp line.

Linac klystron Gallery(08/ 13/ 2011). Water deposited on HV power systems and on 3 relay racks complete equipped with operations devices. Capital lost was substantial.

This quarter the group active worked on developing the plan for these two tasks and getting ready for implementation to commence as much as possible next quarter with the completion date expected during the lab wide fall shutdown 2014.

WBS 1.1.5.3 Vacuum System

Experts are currently, waiting for fall shutdown to start in order to finish installation of the last rougher pump in the Linac tunnel and the 400MeV area turbo pump installation. Some miscellaneous material and parts were ordered this quarter in order to prepare for installation.

WBS 1.2 Booster

Part of the PIP effort for the Booster Accelerator is to address the increase proton beam flux that will be demanded by the Fermilab program in the upcoming years. The increased flux will be achieved by providing beam on more/all of the Booster cycles; certain equipment will increase from an average 7.5 Hz to 15Hz. Overheating of old components is a major concern; several Booster PIP tasks are to upgrade/refurbish equipment to run at 15 Hz.

The aging original equipment and infrastructure of the Booster are vulnerable due to obsolescence and increase wear due to the increase of flux. Some of the PIP effort is to replace these possible reliability problems.

WBS 1.2.1 RF

WBS 1.2.1.1 Anode Supply

Design work has continued through the quarter. The anode supply transformers (ordered at the end of FY13) are in the process of being manufactured. Parts for the anode supply system are being purchased.

WBS 1.2.1.2 Bias Supply

The retrofit of the first bias supply continued. The retrofit is being documented as a procedure for the remaining bias supplies. There are many pieces (cables and cooling pipes) which are being specified as the retrofit proceeds. Heat sink work continues.

WBS 1.2.1.3 *Not Used*

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WBS 1.2.1.4 Cavity Test Stand

The cavity test stand task will not be done since there will be no benefit to PIP.

WBS 1.2.1.5 Cavity and Tuners Refurbishment

The refurbishment of the tenth cavity tuner set was completed this quarter. The time it takes to refurbish and test each set has averaged over the last three sets is a little more than ten weeks. Last quarter, a third cavity-tuner set that had been removed previously was reworked, retested and reinstalled. During the quarter, another previously refurbished cavity developed a severe RF problem; it will be removed from operations. The repair will require cutting the cavity itself open to work on the cavity stem.

Additional manpower has been assigned with a new hire and an additional contractor.

WBS 1.2.1.6 New Tuners

Previously, a high power test stand for ferrite cores showed that one of four different core sets (two different permeabilities from two vendors) was acceptable. The acceptable core samples have been implemented into a tuner and been certified. A purchase order for one set of ferrite cores was done; delivery and testing of these cores are complete. We have been working with the vendor as they establish the correct recipe and process to manufacture ferrite cores with a high permeability. A small order of five cores was delivered and tested. These did barely satisfy the permeability specification but

were slightly the wrong physical dimensions. The vendor has delivered cores that are acceptable. In FY14Q3, we expect enough cores to be delivered so that an entire tuner can be assembled and tested.

WBS 1.2.1.7 New Cavities

Comparison of a model developed for the current Booster RF cavities and the temperature measurements taken as part of the refurbishment task continues. Further tests of cooling rates will be done to be compared with the simulation. A preliminary look into making small improvements to the cavity-tuner design is being done. Detailed temperature measurements were done during cavity and tuner set refurbishment certification (WBS 1.2.1.5); further measurements will be done during the next cavity tuner set certification. In addition, we are starting to investigate possible benefits of using a higher order harmonic cavity; in particular, for beam capture and initial acceleration.

WBS 1.2.1.8 Cavity 1013

The cavity was put under vacuum and is leak tight. The next step is to attach tuners. The existing extra four tuners are being used in the refurbishment task (WBS 1.2.1.5); cavity 1013 will have to wait for new tuners (WBS 1.2.1.6) to be built. This task requires the same manpower as the refurbishment task.

WBS 1.2.2 Accelerator Physics

WBS 1.2.2.1 Simulations and Studies

The people assign to the task of organizing, performing and analyzing beam studies has been consistent for the last few quarters. The main work is being done by an accelerator scientist in the Proton Source Department. There are several physicists from the Accelerator Physics Center also involved. They are in email contact with the original person while they resurrect the codes, procedures and analyses.

The Booster was operational the entire quarter. Work is on-going to smooth the orbit to an ideal orbit (see WBS 1.2.2.2) and measure the optics.

WBS 1.2.2.2 Alignment and Aperture

Currently, no further magnets are scheduled to be moved. There are a few candidate magnets, but current simulation and beam studies (WBS 1.2.2.1) do not suggest that there will be noticeable improvement. The centers of the apertures have been designated as the ideal orbit (see WBS 1.2.2.1). We may return to this task in the future.

WBS 1.2.2.3 Booster Notcher

Assembly of the upgraded power systems was completed this quarter. A completed short kicker magnet has been tested with the upgraded power system. Assembly of the remaining kicker magnets has started after the successful testing of the short kicker magnet. During the next quarter, a part of the upgraded power system will be connected to an operational long kicker magnet.

WBS 1.2.2.4 Booster Cogging

A new electronics board has been used to mimic the existing system. The further capabilities of this prototype board are being implemented and tested. Code development associated with the new board is on-going.

WBS 1.2.2.5 Booster Collimation

The collimation task is to control Booster beam loss after implementing the above notcher and cogging systems.

WBS 1.2.2.6 Radiation Shielding

Beam studies concerning the beam loss profile and measurements of beam loss radiation through penetrations have been done. Additional measurements have been planned and will be conducted in FY14Q3. The studies will involve the effectiveness of the passive shielding, active detectors and determining radioactive source terms for penetrations.

WBS 1.2.3 Instrumentation

WBS 1.2.3.1 Beam Position Monitors

The specifications for the beam position monitor system are nearly complete and initial design work has started.

WBS 1.2.3.2 Dampers

Studies to verify damper design choices continue. Final requirements are being checked.

WBS 1.2.4 *Not Used*

Some WBS numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established during the period of setting up PIP.

WBS 1.2.5 Utilities

WBS 1.2.5.1 Low Conductivity Water System

The task is done.

WBS 1.2.5.2 Power Distribution

The last power transformer is being manufactured; it was ordered at the end of FY13. The transformer will be identical to the two transformers previously purchased by PIP.

WBS 1.2.5.3 Vacuum System

The aged components will be replaced as opportunities present themselves with downtime of the Booster. Previously purchased vacuum equipment awaits opportunities for installation.

WBS 1.2.7 Solid State Upgrade

The task is done.

PIP Budget – Costs and Obligations Updates (FY14 Q2)

This second quarter in FY14 has had no significant budget or labor variances. PIP continues to see a ramp up of labor as work on the MI and Recycler move into a more operational stage. As mentioned in the last quarterly report, progress is being made in several tasks as labor became available (for example, Linac Modulators, Pulsed Notcher Power Supply System and Booster Dampers.) Issues with shortages of labor on some critical tasks such as the critical Booster cavity refurbishment are being addressed. PIP and laboratory management is hopeful that the labor increase will remain in place for the rest of this year.

Table 2 Q2 FY14 PIP OBL Budget

FY14 PIP OBL BUDGET K$	OBL BUDGET	YTD OBL	RIP	BUDGET BAL
M&S	8,611.6	2,967.8	187.9	5,643.8
Labor	5,818.9	2,027.2		3,791.7
FY14 Sums	14,430.5	4,995.0	187.9	9,435.5

evel	VBS	Name	aseline
3	.02.03.02.01.06	MILESTONE: Booster Damper prototype board for transverse system complete	.1/14/1
3	.01.02.03.03.12	MILESTONE: 1st two stages fiber complete	.2/2/13
3	.01.02.03.05.09	MILESTONE: Linac Notch Prototype optical cavity certified (on bench)	.2/26/1
3	.02.03.02.01.08	MILESTONE: Booster Damper prototype board testing complete	./23/14
3	.01.01.02.10.01.09	Milestone: Approval to Build 25 Cell Prototype Modulator	/24/14
3	.01.01.01.03.01.02.10	Milestone: Preliminary Design Review Complete	/18/14
2	.02.01.02.03.05	MILESTONE: First Bias Supply Re-hab Complete	/28/14